module as electromagnetic emission suppression and cooling for the ballast are also available for the power factor circuits.

Referring to the preferred embodiment of Figure 7, there is illustrated a schematic of an electronic ballast 300 for generating the alternating voltage required for an ultraviolet lamp 310. The electronic ballast 300 is composed of a series resonant circuit having an inductor 320 and a capacitor 330 with a resonance frequency of about 135 kHz. The resonant circuit is driven by a driver circuit having two power transistors 340 under the control of integrated circuit (IC) 350. The frequency of the pulses of electrical energy (pulse frequency) provided by the driver circuit to the resonant circuit is determined by lamp power control 360. The pulse frequency is set to vary from 150 to 200 kHz. The closer the pulse frequency is to the resonance frequency, the greater the power transfer to the resonant circuit and therefore the ultraviolet lamp 310. In the preferred embodiment, the maximum power transfer of 100% of lamp power is set to occur at a pulse frequency of 150 kHz, and the minimum power transfer of 50% of lamp power is set to occur at 200 kHz. Alternately, it will be understood by those skilled in the art that other power settings, and pulse and resonance frequency combinations may be used as desired.

Referring to Figure 7, power outlets 370 to UV lamp 310 are isolated from power lines 380 by capacitors 390. The operation of ballast 300 at these high frequencies permits the use of capacitors, instead of relatively large transformers, to provide an additional safety measure.

Referring to Figure 6, control section 230 permits the assembly control unit to control the pulse frequency of the ballast and thereby the power level of the UV lamp between 100% and 50%, and to shut down the UV lamp as desired. Control section 230 further monitors the operating temperature of the ballast module at the hot spots e.g. power transistors 340 in Figure 7. Beyond a certain set temperature, the control section shuts down the ballast and signals the assembly control unit that there has been an over-temperature shut down. Without departing from the scope of this invention, it will be

understood by those skilled in the art that the control section may have more sensors and monitoring functions.

The circuits of a ballast module, as shown in Figure 6, are laid out on a print circuit board encased in a thermal conductive compound within the sleeve of the ballast module. The thermal conductive compound is in contact with the sleeve for an improved thermal path to conduct away the heat.

The IC 350 may be an IC manufactured by Microlinear designated as ML4826. Other chips with the same functionality may also be used.

It will be understood by those skilled in the art that the resonance frequency and the range of the pulse frequency may be set higher or lower and that the range of the pulse frequency can be below the resonance frequency instead of above.

Referring to Figure 8, there is provided a detailed schematic diagram of the best mode implementation of the preferred embodiment of Figure 7 for the resonant circuit and lamp power control of a ballast. The best mode implementation for a ballast module further includes (not shown) circuits for lamp failure detection, current control, voltage control, and communications by a twisted-pair cable.

The present invention is useful for the treatment of a wide range of fluids, e.g. gases and liquids. It is preferable that the fluid is flowing around the radiation source and the excitation controlling means. For example, a rack with attached ballast modules and ultraviolet lamps is immersed in a flowing gas so that a stream of gas flows over the ultraviolet lamps.

The present invention is particularly useful for the treatment of water, e.g. for wastewater disinfection, drinking water disinfection, advanced oxidation treatment and other water treatment processes. The rack with attached ballast modules and ultraviolet lamps preferably is immersed in the water so that a stream of water flows over the ultraviolet lamps. Electrical power is fed to the lamps via the ballast modules, preferably by means of wires or laminates of the present invention through a tubular member of the rack.

One of the advantages of this aspect of the present invention is that the water that is being treated can be used to cool the ballast modules. This removes the necessity for external forced air cooling or for air conditioning equipment. Furthermore, the ballast modules can easily be serviced in situ, removed from service or replaced in the same way that ultraviolet lamps may be serviced or replaced. Any downtime for operation is thus kept to a minimum.

One of the advantages of this aspect of the present invention is that the power levels to the ultraviolet lamps may be individually set. The radiation output from UV lamps decreases with age. A relatively new UV lamp in an assembly may be set at a lower power level than the relatively old UV lamps in the assembly while maintaining the same radiation output level.

Referring to Figure 9, there is shown a partial side view of an alternate UV lamp rack assembly 900 in accordance with the invention. The alternate UV lamp rack 900, partially immersed in a fluid 940 when in use, comprises UV lamps 910 and ballast modules 930 supported in an elongate frame member 920. Each of the ballast modules 930 is electrically connected to at least one UV lamp 910. Preferably, each of the ballast modules 930 is connected in proximity to only one UV lamp 910. It will be understand that the ballast modules 930 may be arranged in various configurations with the member 920 and the UV lamps 910.

It will be understood that the present invention is applicable to low pressure standard output lamps, low pressure high output lamps, low pressure amalgam lamps, medium pressure lamps, electrodeless lamps and excimer lamps.

It will be understood that the present invention may be applied to treatment of fluids other than just water or wastewater.

It will be understood that the ballast in the present invention may be operated over extremely wide frequency settings for the resonance and pulse frequencies. It is anticipated that the resonance frequency and pulse frequency range may be set over at least 50 kHz to 1MHz.